

## RUNWAY-INDEPENDENT OMNI-ROLE MODULARITY ENHANCEMENT (ROME) VEHICLE

### FIELD OF THE INVENTION

5           **[0001]**   The present invention relates generally to flight capable mobile platforms and more specifically to a modularly designed vertical or near-vertical takeoff aircraft.

### BACKGROUND OF THE INVENTION

10           **[0002]**   Current military doctrine relies on a limited number of high value assets to prosecute global events. The restriction to a one-man (or more) to one machine system severely impairs these finite forces' ability to overcome overwhelming hostile force numbers and/or engage several theatres of operation simultaneously. Additionally, a severe lack of commonality between the vehicles  
15           used by individual services of the armed forces has increased the cost of those platforms while restricting their interoperability between services and NATO allies.

**[0003]**   The extremely complex and multiple part machinery used by the armed forces has several disadvantages. The initial cost to construct each unit is  
20           high. The follow-on cost to maintain each unit is also high due to the complexity of the systems in use. Additionally, highly complex machinery is more susceptible to damage and breakdown due to large numbers of moving parts, heavy reliance on software based computing systems for control and operation, and reliance on large numbers of highly trained maintenance personnel to  
25           maintain each vehicle.

**[0004]**   For military use aircraft, either vertical takeoff/landing, or very short takeoff and landing aircraft are particularly complex and expensive systems both to procure and maintain. The advantage of short or vertical takeoff aircraft is a greatly reduced length for takeoff and/or landing strips, which enable broader  
30           use of the aircraft in areas lacking these facilities. This advantage is partially negated when one takes into account the susceptibility to damage of the system in unimproved areas and the relatively significant maintenance infrastructure the complex system requires.

[0005] It is therefore desirable to provide a modularly constructed aircraft to decrease the initial cost of each platform as well as to increase the number of and type of missions the aircraft can be modified to fly. It is also desirable to combine modular aircraft construction features with an aircraft having  
5 modularized and simplified vertical takeoff and landing propulsion devices.

## SUMMARY OF THE INVENTION

[0006] According to a preferred embodiment of the present invention, a modular component set is configurable to form a plurality of flight capable  
10 platforms. A plurality of end pieces each have a shaped tip portion and contiguously connected curved outer portions each longitudinally expanding from the tip to terminate at a blunt attachment face. A plurality of body members have opposed ends adapted to receive the end piece blunt attachment face, and a rectangular shaped mid portion having opposed walls. A plurality of task specific  
15 panels are each releasably connectable to one of the opposed walls. At least one of the body members with the end pieces joined at the opposed ends, and at least one of the task specific panels connected to one of the opposed walls form a minimum component set for each of the flight capable platforms.

[0007] In one preferred embodiment, at least one vertical propulsion  
20 device is disposed in each of the body members. Two or more body members can then be joined either longitudinally or arranged in parallel sets. When parallel sets of the body members are formed, a payload bay is connectable between the two sets. A common nose/tail section is connectable to either end of each of the body members. Spacer members are used between parallel adjoining pairs of  
25 the nose/tail sections. One or more wing designs are mountable to the body members. Flight control surfaces are also mountable to either of the spacer members or the nose/tail sections.

[0008] The task specific panels of the present invention are releasably attached to walls of the body members. Each of the task specific panels can  
30 mount a different task item, including missiles, torpedoes, sonobuoys, rockets, radar, and additional items such as fuel and power sources, etc. The task specific panels are interchangeable between individual flights of the aircraft of the present invention. Control equipment, energy sources such as batteries, and

mechanical connecting equipment are examples of equipment which can be mounted within an envelope of the task specific panels. Except for required aircraft interface equipment, each task specific panel therefore acts as a stand-alone module. Different types of equipment can also be loaded on opposite  
5 panels of a particular aircraft. The task specific panels are structurally integrated into the body member walls such that a portion of the load imparted by the task devices as well as the panel itself are integrated into the body members, and body member loads are also similarly transferable to or through the task specific panels.

10       **[0009]** Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the invention.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

20       **[0011]** Figure 1 is an exploded perspective view of modular aircraft according to a preferred embodiment of the present invention;

**[0012]** Figure 2 is an assembled perspective view of the modular aircraft of Figure 1 further showing an exemplary horizontal propulsion device and a task specific set of items mounted to the aircraft panel;

25       **[0013]** Figure 3 is a perspective view of another embodiment of a modular aircraft of the present invention having a longitudinally joined pair of body sections and two separate pairs of wings;

**[0014]** Figure 4 is a perspective view of a task specific panel of the present invention showing an exemplary missile attached thereto;

30       **[0015]** Figure 5 is a perspective view of an exemplary task specific panel showing a torpedo attached thereto;

**[0016]** Figure 6 is a perspective view of an exemplary task specific panel showing a sonobuoy package attached thereto;

[0017] Figure 7 is a exemplary task specific panel showing a pair of rockets attached thereto;

[0018] Figure 8 is a perspective view of an exemplary task specific panel showing a radar module attached thereto and a modified exterior face  
5 providing additional volume for radar associated equipment;

[0019] Figure 9 is a perspective view of another embodiment of a modular aircraft of the present invention having multiple joined body sections, a payload bay, and spacer members attached thereto;

[0020] Figure 10 is a perspective view similar to Figure 9 showing an  
10 exemplary rudder and horizontal stabilizer pair attached to an aft spacer member;

[0021] Figure 11 is a sectioned elevation view taken at Section 11-11 of Figure 2, showing an alternate embodiment of the present invention;

[0022] Figure 12 is a sectioned elevation view similar to Figure 11, showing another embodiment of the present invention; and

[0023] Figure 13 is a flow diagram describing a method to modularly  
15 construct an aircraft of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] The following description of the preferred embodiments is  
20 merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0025] According to a preferred embodiment of the present invention, shown in Figure 1, a mobile platform 10 in accordance with one preferred embodiment of the present invention is shown. The mobile platform 10 forms a  
25 modular aircraft, and will be referred to for convenience by the term “modular aircraft “ 10 herein. Modular aircraft 10 includes at least one body section 12 having a forward attachment face 14 and an aft attachment face 16. The body sections 12 each include a starboard wall 18 and a port wall 20, respectively. Each of the body sections 12 further includes at least one vertical propulsion  
30 device 22. Figure 1 shows an exemplary set of six vertical propulsion devices 22, which in this example include augmented pulsejet engines. The augmented pulsejet engines are disclosed in co-pending United States Patent Application Serial No. 10/245,519 commonly assigned to the assignee of the present

invention, and entitled "Pulsejet Ejector Thrust Augmentor", filed September 16, 2002, the disclosure of which is incorporated herein by reference.

5       **[0026]** Each body section 12 further includes a cavity 24 formed in each of the starboard wall 18 and the port wall 20. A plurality of fastener apertures 26 are shown around a perimeter of the cavity 24 (the port cavity is shown for clarity only). A task specific panel 28 is connectably fastened to each of the cavities 24 using each of a plurality of fasteners 30 which align through a plurality of apertures 32 in coalignment with each of the fastener apertures 26. The task specific panels 28 will be described in further detail in reference to  
10       Figures 4-8.

**[0027]** An end piece 34 is connectably joined to both the forward attachment face 14 and the aft attachment face 16 of the body section 12, using fasteners (not shown) or alternate attachment devices including adhesives, rivets, welding, and clips. Each end piece 34 includes a tip 36 and a plurality of  
15       contiguous rounded sides 38. Each of the rounded sides 38 ends at a blunt attachment face 40. The blunt attachment face 40 is dimensionally controlled to the approximate geometry and perimeter of each of the forward attachment face 14 and the aft attachment face 16 of body section 12. A starboard wing 42 and a port wing (not shown for clarity) are attached to the body section 12 at a location  
20       on either of the starboard wall 18 or the port wall 28 preferably above or optionally below the location of the task specific panels 28. Pulsejets 43 embedded in winglets of wings 42 can be differentially controlled for roll control. At least one of the body sections 12, at least two of the end pieces 34, and at least one of the task specific panels 28 connected to one of the starboard or port  
25       walls 18 and 20, respectfully, forms a minimum component set for the modular aircraft 10.

**[0028]** Referring next to Figure 2, an assembled modular aircraft 44 using the basic parts identified in Figure 1 and additional components is shown. Modular aircraft 44 includes a single body section 12 having a pair of end pieces  
30       34 forming a forward or nose section and an aft or tail section, respectively. A pair of members 46 are connected to the aft located end piece 34. Each of the members 46 perform several functions, including acting as flight control surfaces for steering the modular aircraft 44 and as ground supporting members for the

modular aircraft 44 when in a landed or stored position. The task specific panel 28 shown is modified to include a pair of rockets 48. Forward propulsion for the modular aircraft 44 is provided by a propeller 50. Engine components (not shown for clarity) connectable to the propeller 50 are disposed in the end piece 34 acting  
5 as the tail section of the modular aircraft 44. Fuel for the modular aircraft 44 is provided in either or both of the end pieces 34, as well as in excess volume located in body section 12 (e.g., area near wing attachment).

[0029] Modular aircraft 44 is envisioned as an unmanned aircraft, having internal flight guidance and control equipment (not shown) for remote  
10 flight control of modular aircraft 44. It should be obvious the size of modular aircraft 44 can be varied, depending on the size of the individual component parts and the desired mission of modular aircraft 44.

[0030] Referring next to Figure 3, a modular aircraft 52 according to another embodiment of the present invention is shown. Modular aircraft 52  
15 includes a forward body section 54 and an aft body section 56, respectively, both similar to body section 12 described in reference to Figure 1. Modular aircraft 52 is formed by joining forward attachment face 14 of aft body section 56 to aft attachment face 16 (shown in Figure 1) of forward body section 54. By joining two body sections together in longitudinal alignment as shown, both a forward  
20 task specific panel 58 and an aft task specific panel 60 can be mounted to both sides of modular aircraft 52. Forward and aft ends of modular aircraft 52 are formed by end pieces 34, similar to those described in reference to Figure 1. Modular aircraft 52 also includes two pairs of wings 42.

[0031] As best described in references to Figures 4-8, a plurality of task  
25 specific panels 28 are described. As shown in Figure 4, an exemplary task specific panel 28 includes an exterior face 62 and an interior face 64. Exterior face 62 is modified to provide support for a missile 66. Each of the task specific panels 28 has a minimum panel depth "A." The function of panel depth "A" is to permit internal incorporation of electronics, guidance, fuel, and similar features  
30 required to interface with missile 66 or any equipment mounted to one of the task specific panels 28. Panel depth "A" approximately matches a depth of cavity 24 (shown in Figure 1) such that each task specific panel 28 acts as a structural member when joined with the structure of body section 12.

[0032] As best seen in Figure 5, a panel 68 is modified to support a torpedo 70. As shown in Figure 6, a panel 72 is modified to support a sonobuoy package 74 which includes a plurality of sonobuoy delivery tubes 76. As best seen in Figure 7, a panel 78 is modified to support the pair of rockets 48. As a further example of a task specific panel 28, Figure 8 shows a panel 80 modified to incorporate an exemplary synthetic aperture radar module 82 and an electro-optical infra red camera 83. An exterior face 84 of panel 80 has an expanded panel depth "B" permitting incorporation of radar associated equipment (not shown) within the depth of panel 80. It should be obvious that Figures 4-8 represent exemplary designs for task specific panels 28. Figures 4-8 generally describe military applications for the task specific panels 28. Commercial and civilian uses for task specific panels 28 are also possible, including but not limited to, cameras for surveillance operation, weather-related radar equipment, support racks for carrying wounded personnel, crop spraying nuclear/biological/chemical detection, high value package delivery, and fish finding, etc. The invention is not limited to the devices mounted to a specific task specific panel 28. Each of the panels identified in Figures 4-8 (as well as panels not shown) are removably fastened to an aircraft of the present invention such that each flight of the aircraft can include a different task specific panel for a different operation of the aircraft.

[0033] In a further preferred embodiment, and referring to Figure 9, a modular aircraft 85 includes a starboard body section pair 86 and a port body section pair 88. Each of the starboard body section pair 86 and the port body section pair 88 are formed similar to the combination of forward body section 54 and aft body section 56 shown in Figure 3. The starboard body section pair 86 and the port body section pair 88 are arranged in parallel. A forward starboard end piece 90 and a forward port end piece 92 are joined to the starboard body section pair 86 and the port body section pair 88 forward ends, respectively. A forward spacer member 94 is connectably disposed between forward starboard end piece 90 and forward port end piece 92. An aft end of modular aircraft 85 is similarly formed by an aft starboard end piece 96, an aft port end piece 98 and an aft spacer member 100. Providing each of the forward spacer member 94 and the aft spacer member 100 permits incorporation of a payload bay 102. Based on the increased size and operating weight of modular aircraft 85, an increased

size wing pair 104 and a propeller pair 105 are incorporated therein. Similar to modular aircraft 52 shown in Figure 3, modular aircraft 85 incorporates two task specific panels per side.

5       **[0034]** Referring to Figure 10, a modular aircraft 106 includes a rudder section 108 and a horizontal stabilizer pair 110 connectably disposed to an aft spacer member 112. Similar to modular aircraft 52 shown in Figure 3, modular aircraft 106 incorporates two task specific panels per side.

10       **[0035]** For commonality, it is noted that the same geometry and construction features are incorporated in each of the end pieces 34, forward starboard end piece 90, forward port end piece 92, aft starboard end piece 96 and aft port end piece 98 respectively. Similarly, each of the forward body section 54, aft body section 56, starboard body section pair 86, and port body section pair 88 are formed from one or more body sections 12, shown and described in reference to Figure 1. Each body section 12 is a generally  
15 rectangular shaped section incorporating at least one of the vertical propulsion devices 22. In one preferred embodiment, pulsejet ejector engines are used for vertical propulsion devices 22 in each body section 12. Alternate vertical propulsion sources can also be incorporated in body sections 12, including, but not limited to jet engines, rotating propeller sections, or rocket engines.  
20 Propellers are described herein for horizontal propulsion of modular aircraft of the present invention, however, alternate horizontal propulsion engines can also be used including jet engines, turbo jet engines, and pulsejet engines. Such horizontal propulsion engine(s) could occupy end piece(s) 34 or task specific panel(s) 28.

25       **[0036]** Referring to Figure 11, a cross section through another embodiment of a body section 12 includes a pulsejet ejector thrust augmentor cavity 120 which is centrally positioned in a body structure 122. A task specific panel 124 and a task specific panel 126 are shown in each of an installed an a  
30 uninstalled position, respectively. A supply/support duct 128 supports task specific panel 124 and a supply/support duct 130 supports task specific panel 126, respectively. Each of the task specific panels 124 and 126 include a plurality of through-apertures 132 positioned at an upper position thereof. Each of the through-apertures 132 co-axially align with a fastener retention aperture



134 disposed in body structure 122. An exemplary installation of task specific panel 126 is as follows. The supply/support duct 130 is connected to task specific panel 126 and a tapered end 136 is slidably mated into a tapered slot 138 of body structure 122. Task specific panel 126 is rotated about panel installation arc C until the panel mates with a seating face 139. Each of a plurality of fasteners 30 are installed in through-apertures 132 to mate with each of the fastener retention apertures 134 to firmly attach the task specific panel 126. Task specific panel 124 is shown in its installed position.

[0037] Referring next to Figure 12, another embodiment which is modified from that shown in Figure 11 is provided. Only the differences between the embodiment shown in Figure 11 and Figure 12 will be discussed herein. Body section 140 supports a task specific panel 142 and a task specific panel 144 (shown in phantom). Each of the task specific panels 142 and 144 include an engagement end 146 at opposed ends of the task specific panels. Each engagement end 146 mates with a corresponding engagement slot 148 formed in body section 140. A plurality of rotational cams 150 are provided which are rotatably connected to body section 140 and rotate about cam rotation arc D from an open position (shown on the right side of Figure 12) to a closed and latched position (shown on the left side of Figure 12). Rotatable cams 150 are designed to engage each of the engagement ends 146 to firmly support both ends of task specific panels 142 and 144. Each task specific panel 142 and 144 can be loaded either horizontally (similar to the direction shown in Figure 1) or alternately can be slid in a fore/aft direction through select ones of the end pieces 34 via openings (not shown) in the end piece 34. The openings can themselves be closed or sealed after installation of the task specific panel.

[0038] Referring finally to Figure 13, the steps to construct a modular aircraft of the present invention are described. In a disposition step 200, a vertical propulsion system is disposed into a body section. At a fastening step 202, at least one task specific panel is releasably fastened to the body section. In an installation step 204, a set of task specific equipment is installed on each task specific panel. In a mounting step 206, a wing pair is mounted to the body section to form the aircraft of the present invention. In a first parallel step 208, at least two of the body sections are connected together. In a second parallel step

210, a rounded section or end piece is connected on each free end of the body sections.

[0039] A modular aircraft of the present invention offers several advantages. By incorporating vertical propulsion engines into common body sections, one or more body sections can be joined which provide a general fuselage shape for an aircraft design. By using a commonly shaped end piece, both forward and aft free ends of the body sections are provided with a commonly designed and installed end piece. By spacing two or more parallel aligned body sections, a payload bay can be incorporated as well as common spacer members between the end pieces. By incorporating task specific panels to the sides of each of the body members, each modular aircraft of the present invention can fly multiple missions after removal and reattachment of one of a plurality of mission specific equipment panels. The modular design of the present invention permits multiple uses including military, commercial and private for aircraft of the present invention. By incorporating control and electronic equipment supporting each package mounted from a task specific panel of the present invention, each task specific panel provides a self-contained unit of the necessary task specific equipment associated with the mission. Also, by utilizing aircraft flight control surfaces extending from an aft end of the aircraft as a simplified landing gear, a modular aircraft of the present invention can land and be reused for multiple missions. Maintenance on a modular aircraft of the present invention is also simplified because common component parts are used and are therefore replaceable if damaged or required for alternate missions.

[0040] Materials for a modular aircraft of the present invention are preferably of light weight and high strength. The end pieces are preferably constructed of an elastomeric (i.e., plastic) or fiber reinforced material such as fiberglass, or carbon fiber to minimize weight and provide an inexpensive, replaceable material. Similar materials are also preferably used for the spacer members as well as component parts of the payload bay. Due to the heat generated by the vertical propulsion engines and the need for strong/rigid load bearing structure, one preferred material for the body section(s) is a stainless steel or similar steel, or a metal or alloy which can both withstand the exhaust heat of the vertical propulsion engines and provide structural rigidity for mounting

the various components, and supporting the wings of the modular aircraft of the present invention. Materials for the wings are similarly preferably manufactured of elastomeric or composite materials. It should also be noted, however, that the elastomeric materials referred to herein can be replaced by metals such as aluminum or titanium if desirable to provide a higher strength yet still light-weight modular aircraft.

[0041] It is anticipated that although most of the support equipment for a mission is incorporated in the task specific panel, some connectivity between the body section and the task specific panel may be required such as mechanical release mechanisms and/or electronic cabling to support location, guidance data, or fuel for a mission specific piece of equipment, which can be provided from the body section. It is also noted that the payload bay identified herein can be increased in size sufficient that a manned modular aircraft of the present invention can be provided. This will require some modification to the forward spacer member 94 (shown in Figure 9), for example to include a windshield (not shown) for visibility. A landing gear set similar to that used for common military or commercial aircraft can also be incorporated in a modular aircraft of the present invention, particularly if manned flight is required.

[0042] A modular aircraft of the present invention, in one preferred form, may comprise a subsonic speed aircraft. The capability provided by the vertical propulsion engines provides each modular aircraft of the present invention with the advantage of a vertical or nearly vertical takeoff operation. This greatly increases the range of use for the modular aircraft of the present invention to areas where runways are not available as well as to those areas where runways are available. The preferred use of pulsejet ejector engines in a vertical takeoff aircraft is disclosed in co-pending United States Patent Application Serial No. 10/245,145 commonly assigned to the assignee of the present invention, and filed on September 16, 2002, the disclosure of which is incorporated herein by reference. The use of pulsejet ejector engines in vertical takeoff aircraft permits a low cost, low maintenance modular aircraft of the present invention both a vertical takeoff and landing capability as well as a limited hovering capability.

[0043] A modular aircraft as described herein is exemplary in that the invention can be applied to any mobile platform, and particularly to any flight capable mobile platform. The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are  
5 intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.